HYDROGEOLOGICAL STUDY REPORT OF OXEL SPRING
IN SIOLIM VILLAGE, TALUKA BARDEZ, NORTH GOA DISTRICT, GOA

REPORT BY

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1.0. INTRODUCTION

1.1. Background

This hydrogeological study was carried out in the month of September 2024 for Oxel Spring that extends in SurveyNo. 51/22 and 51/21 of upcoming construction of Siolim village, Taluka Bardez, North Goa District, Goa. The study has been carried out on the request of residents of Aradi, Siolim Village.

1.1.2. Location:

The study area is located at about 20 Km North West of Panjim City in North Goa District. The Oxel Spring is situated at about 10 km from Mapusa city. It is accessible by road.

1.1.1 Study Area:

The study area, Oxel spring discharges into the Chapora river. It is included in the Survey of India toposheet No. 48E_14 on 1;50,000 scale (Fig. 1). Oxel Spring is dominantly located in Survey 51/22, Oxel, Siolim village, Taluka Bardez, North Goa District, Goa.

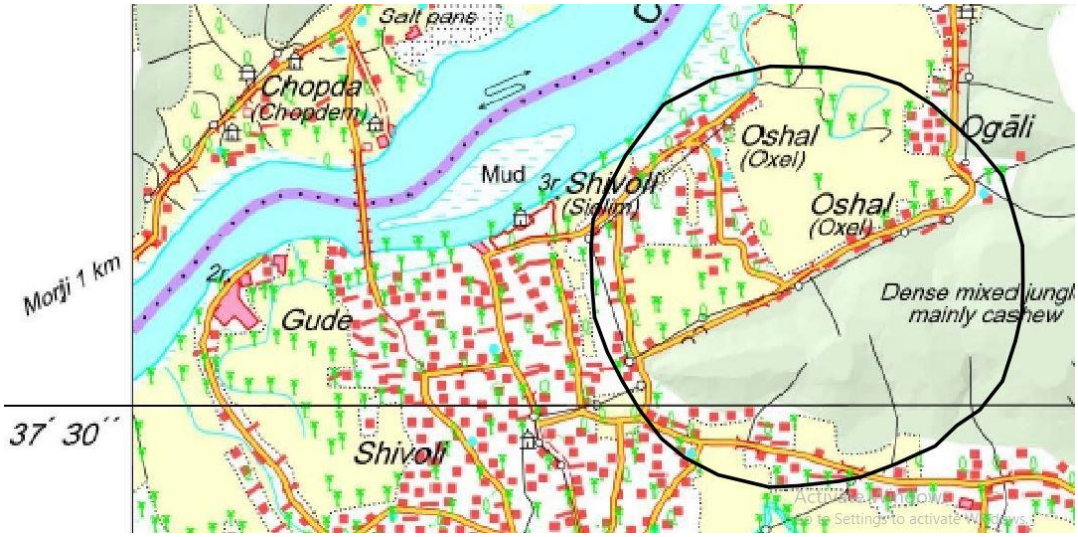


Figure 1: Map showing the location of the Oxel Spring in the SOI toposheet.

1.2. General Geology

Physiographically North Goa district can be broadly divided into four distinct morphological units from west to east namely,

(i) Coastal plain with marine land forms on the west,

(ii) Vast stretch of plains adjoining the coastal plain,

(iii) Low dissected denudational hills & tablelands towards the east, and

(iv) Deeply dissected high Western Ghats denudational hills along the eastern most part of the district.

North Goa district is dominantly covered by the formations of Goa Group belonging to Dharwar Super Group of Archaean to Proterozoic age. Deccan Trap of Upper Cretaceous occupies a narrow strip along the northeastern corner to Lower Eocene age.

The Goa Group comprises of metamorphic rocks of green schist facies, and is divided into Barcem, Sanvordem, Bicholim and Vageri formation in the ascending order of superposition (Fig. 2). The Goa Group of rocks has been intruded by granite gneiss, feldspathic gneiss, hornblende gneiss and porphyritic granite, followed by basic intrusives.

During the Sub – Recent and Recent times, the rocks have been subjected to lateritisation of varying thickness. Thus, laterite occurs extensively covering almost all the formations in North Goa district. Coastal alluvium occurring along the coastal plains consists of fine to coarse sands with intercalations of sandy loam, silt and clay.

The study area is located in the Sanvordem formation of rocks dominantly made up of Quartz Chlorite Biotite Schist. These are covered by a thick layer of laterite.

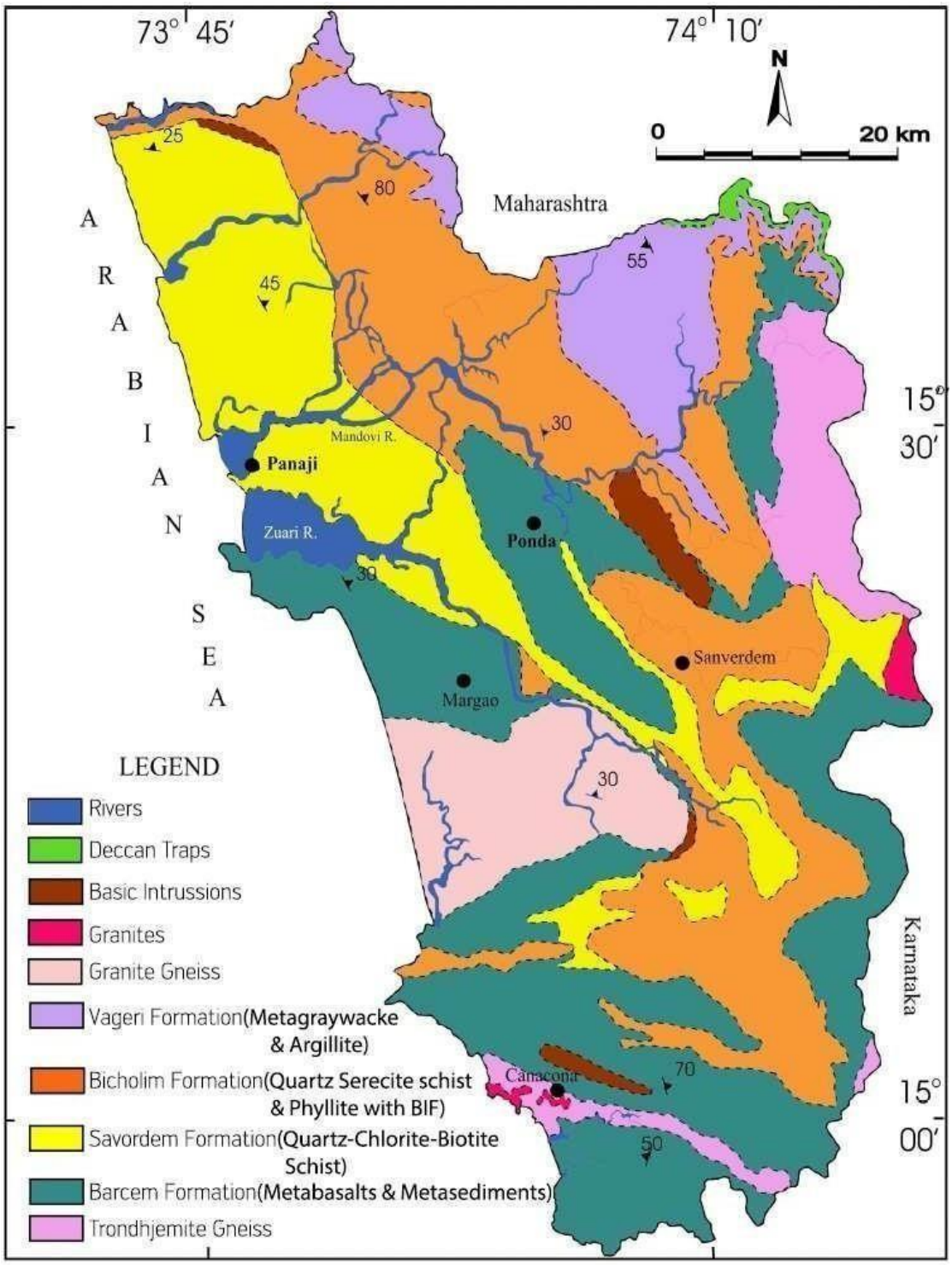


Figure 2: Geological map of Goa (published by GSI)

1.3. Hydrogeology

Occurrence and movement of ground water depends upon the type of rock formation, structure, topography, rainfall, recharge etc. Ground water in North Goa district occurs in rocks having primary porosity & permeability or in those having secondary porosity acquired due to weathering, leaking, tectonics, solutions etc. Ground water bearing formations in the district are laterite, alluvium, metavolcanics and metasedimentaries. Hydrogeological map is illustrated in Fig. 3.

1.4. Rainfall in North Goa District

Due to orographic influence, rainfall increases from the coast towards to the Western Ghats, with average annual rainfall 2828.70 mm (in Bardez taluka) to 3948.30 mm (in Sattari taluka).

Over 90% of annual rainfall occurs during monsoon months of June to September. About 32% of the annual rainfall is received during July.

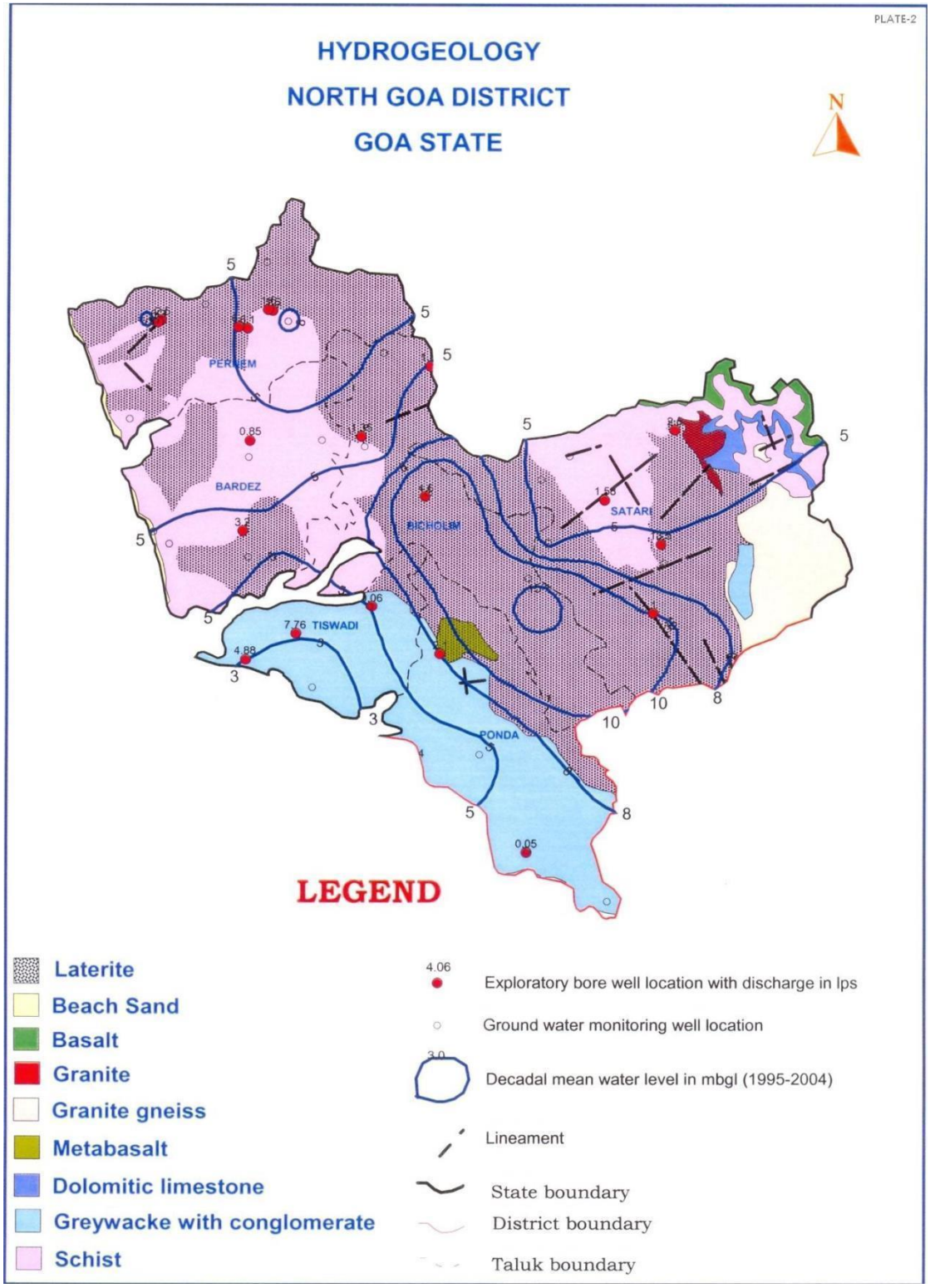


Figure 3: Hydrogeological map of North Goa (GW Info Booklet North Goa District CGWB, March 2013)

2.0. Aims and Objectives

2.1. Aim

To conduct hydrogeological Study of Oxel Spring and its surrounding wells in Siolim Village, Taluka Bardez, North Goa district, Goa to identify any potential threat to the spring due to construction activity in the vicinity.

2.2. Objective

1. To identify any potential threats to the Oxel Spring for it's flow and contamination of the Oxel spring.

3.0 METHODOLOGY

The study methods included study of the SOI toposheet of the area, google earth imageries of the area, reconnaissance survey of the study area, physical traverse across the area, mapping of the water sources and water bodies in the area and geophysical survey.

Mapping of the water sources and water bodies was carried out both in the month of September 2024. The streams, springs and the wells were carefully mapped. A contour map (Fig. 4) and a drainage map (Fig. 5) has been prepared using the data.

Geophysical Survey of the study area was carried out in the month of October 2024.

A single type of Geophysical method was adopted to survey the area i.e. Very Low Frequency Electromagnetic (VLF-EM) profiling. The VLF-EM profiling gives the lateral variation in the resistivity of the ground.

3.1 Basis of Geophysical methods

All the methods of exploration geophysics are based on some physical properties like density, magnetic susceptibility, elasticity, radio activity and electrical resistivity (or electrical conductivity). Due to the differences in lithological and chemical composition different rock types have different physical properties. Electrical methods depend upon the electrical conductivities (or resistivity) of different rocks and minerals. When we pass a current of electricity into the ground, the current will distribute itself according to the conductivities of the rocks and minerals coming under the influence of current. There will be appreciable concentration of current in places where there are large masses of highly conductive bodies. Hence it is the electrical resistivity or electrical conductivity that is used as the physical property in electrical methods.

3.2 VLF EM method

VLF – EM Geophysical instrument finds physical structures in the ground and bed rock. VLF – EM instrument operates on the VLF principle and it makes use of radio waves in the VLF band sent out from distant transmitters. VLF –EM instrument utilizes the magnetic components of the electromagnetic field generated by military radio transmitters that use the VLF frequency band (Very Low Frequency 15 – 30 KHz). They are used mostly for the long-distance communication.

Electrically conductive structures on the surface or under-ground even when covered with thick over burden, affect locally the direction and strength of the field generated by the transmitted radio signal. A weak secondary field builds up around the geological structure. This field can be measured and analysed. This VLF-EM instrument measures the field strength and Phase displacement around a fractured zone in the rock. When the electromagnetic field from a VLF

transmitter passes through a conductive body, secondary currents will grow up in the body. This is the principle of induction. These secondary currents will in turn generate a magnetic field, a secondary field which will try to repel the primary field. Only a body with a low electrical resistivity can generate secondary fields.

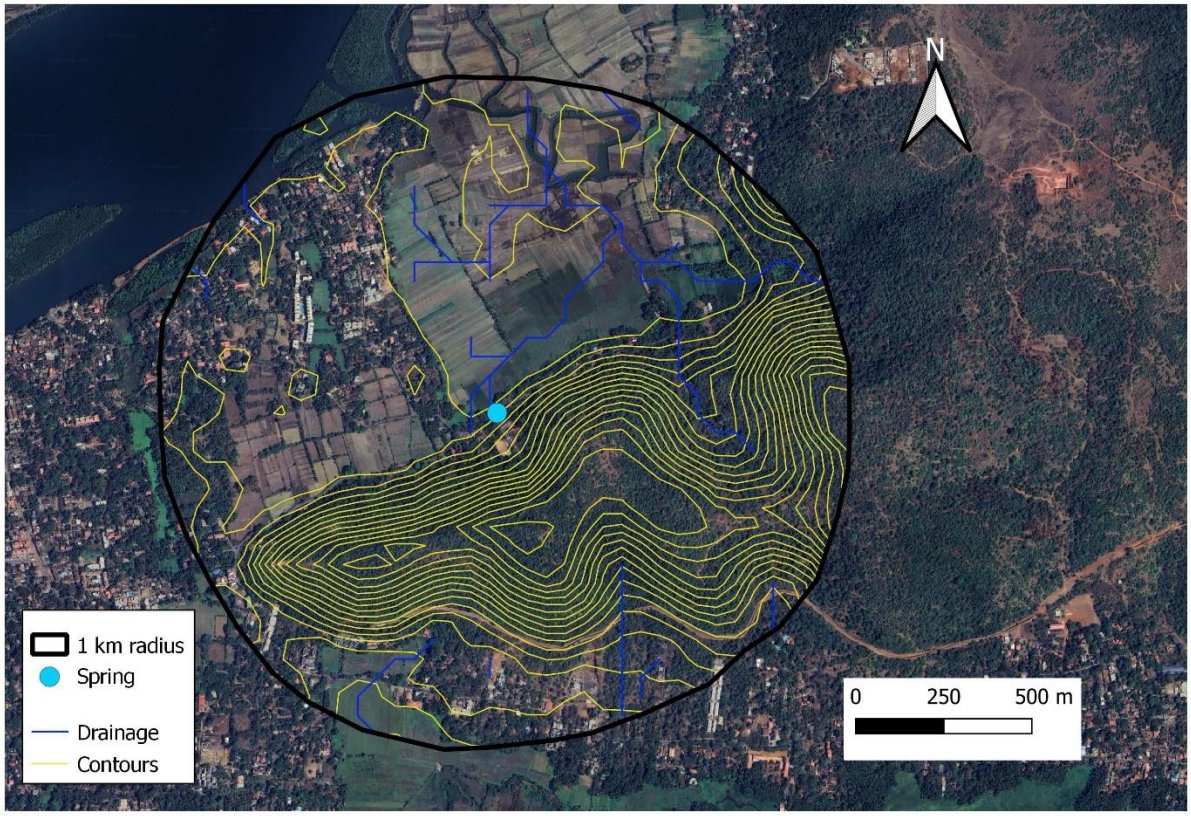


Figure 4: Contour Map of the Oxel Spring

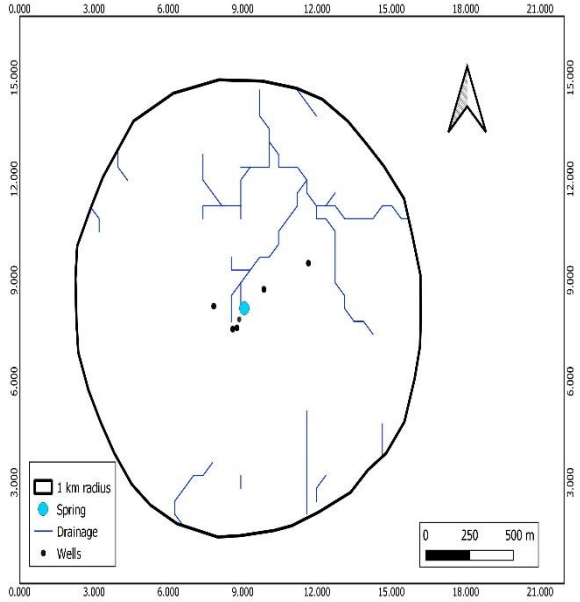


Figure 5: Drainage map of the Oxel Spring

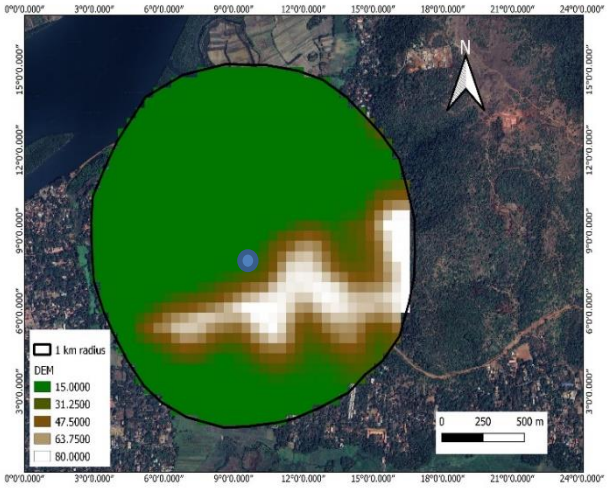


Figure 6: Digital Elevation Map of Oxel Spring

4.0 FIELD OBSERVATIONS AND DATA ANALYSIS

Oxel is a village in Bardez Taluka, Goa, bounded by Siolim to the west, Camurlim to the east, hills in the South and river Chapora to the North. There are six springs in Oxel. The springs are located along Khoirat- Arradi stretch. The springs provide water, some of which is used for drinking.

The spring, popularly known as “Padigarachi Zor”, is in Aradi by the roadside at the foot of a hillock on which sits the Our Lady of the Sea church. This particular spring has been renovated by the water resources department for better preservation and access. The area surrounding the spring is characterized by the presence of coconut and cashew plantation as well as paddy field indicating a diverse agro ecosystem.

Springs occur due to the natural pressure in an aquifer, where the groundwater is forced to the surface as a result of recharge from rainfall. Water moves through the cracks and tunnels in the aquifer and emerges at the surface when pressure builds. Springs are a part of the hydrosphere and play a role in the water cycle. The spring in Oxel is over 100 years indicating a long standing hydrological future. The spring maintains a continuous flow even during the summer months and does not dry up.

Current challenges associated with Spring

Anthropogenic pressures, characterized by rising resident populations and increased tourist inflow, are exerting significant stress on mountain aquifer systems. Ecological degradation driven by land use and land cover changes, particularly due to infrastructure development, is resulting in the reduction of natural recharge areas for springs and a concomitant decline in spring water quality. The depletion of spring water resources poses serious implications for the livelihoods of both local residents and visitors in mountainous regions. Furthermore, pollution stemming from waste generated by recreational activities exacerbates these challenges. Key issues include the over-extraction of groundwater and the introduction of contaminants, particularly nutrients such as nitrogen and agrochemicals from intensive agricultural practices, which adversely affect spring ecosystems and their functionality.

Sr. No.	Lat	Long
Spring	15°37’49”N	73°46’42”E
Well 1	15°37’13”N	73°46’49”E
Well 2	15°37’98”N	73°46’57”E
Well 3	15°37’76”N	73°46’75”E

Well 4	15°37’56”N	73°46’54”E
Well 5	15°37’47”N	73°46’42”E
Well 6	15°37’49”N	73°46’36”E

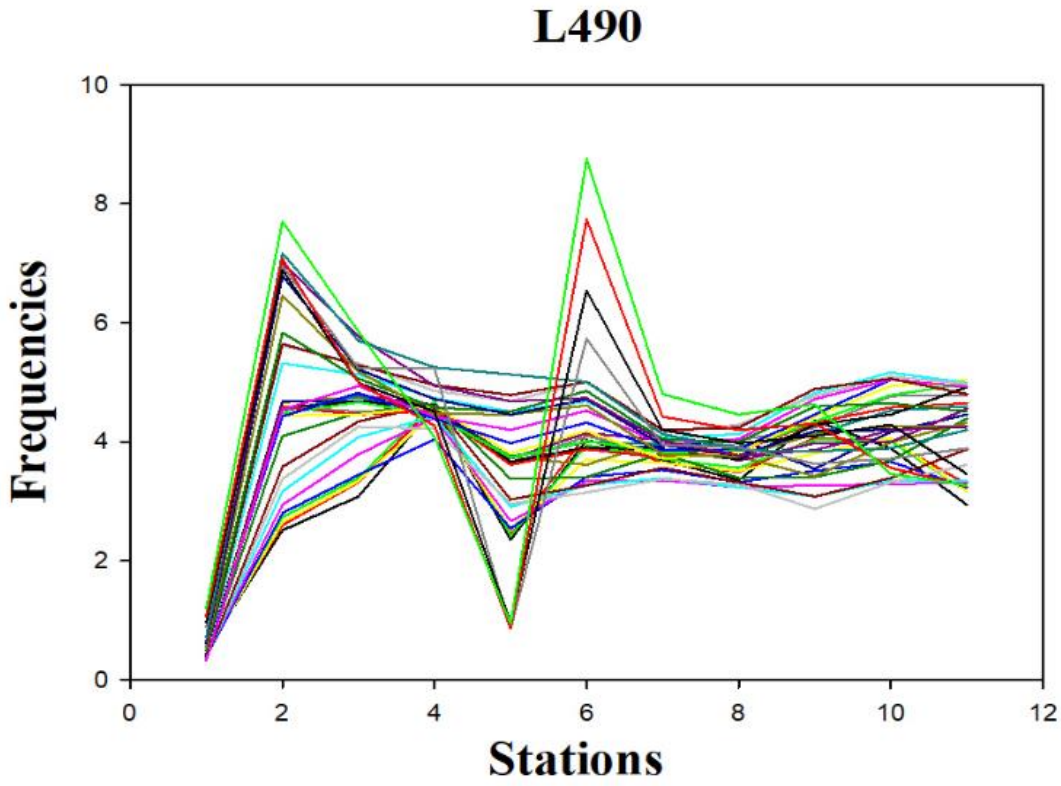
To understand the nature of occurrence of groundwater in the subsurface, lateral geophysical survey profiling was conducted up to depth of 100m. Very Low Frequency Electromagnetic (VLF- EM) profiles in the North-South, East-West directions were carried out inthe area. A total of 5 electromagnetic profiles namely L490, L491, L492, L493 and L494 were carried out in the area.

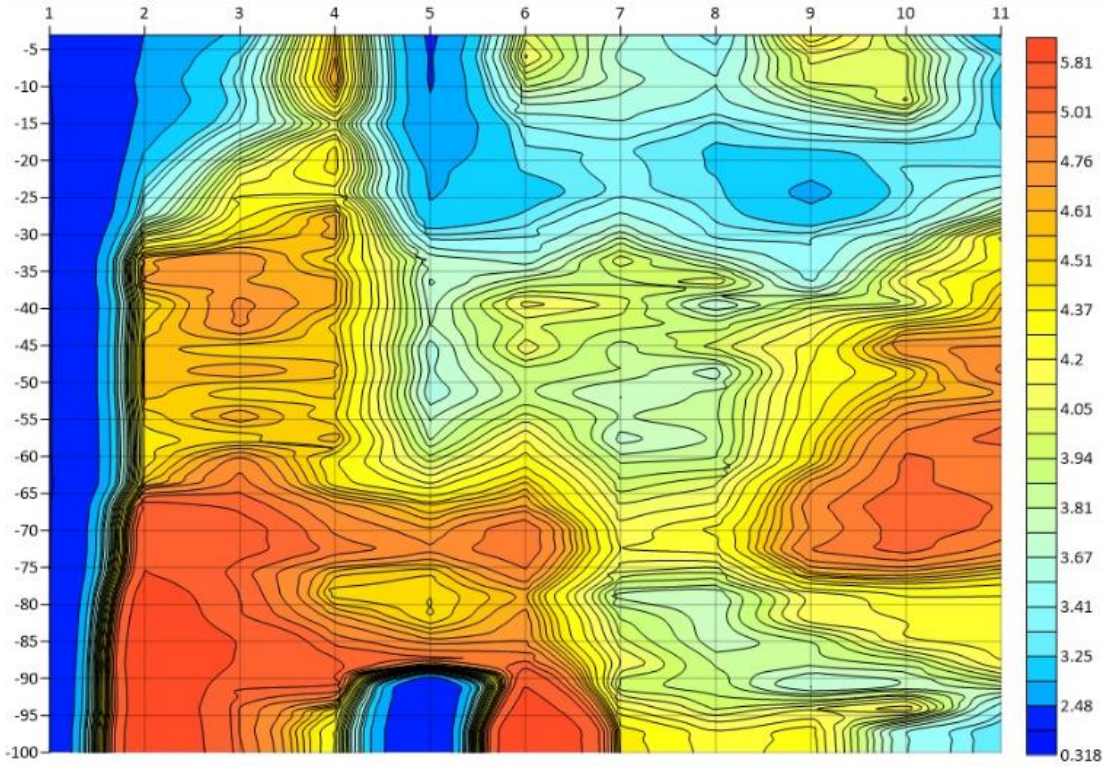
The VLF profile details are mentioned in the table below: Table 1.

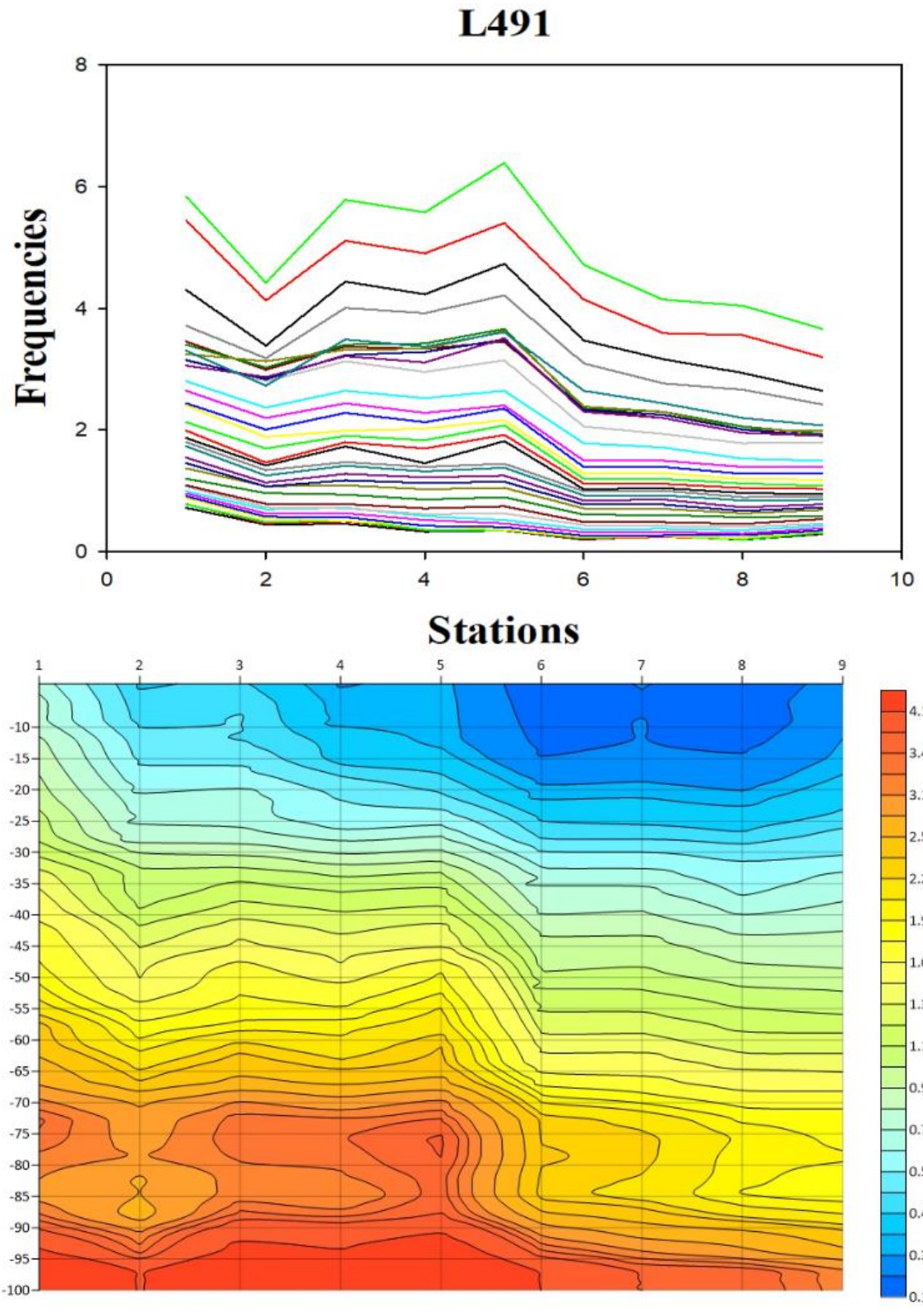
Sr. No.	**Profile No**	**Total Profile Length (m)**	**Direction of the profiles**
1	**L490**	**22**	**NW-SE**
2	**L491**	**9**	**NW-SE**
3	**L492**	**5**	**NW-SE**
4	**L493**	**3**	**NW-SE**
5	**L494**	**7**	**NW-SE**

ANNEXURE I : CURVE GRAPHS AND PROFILE SECTION

PROFILE SURVEY






L491
Frequencies
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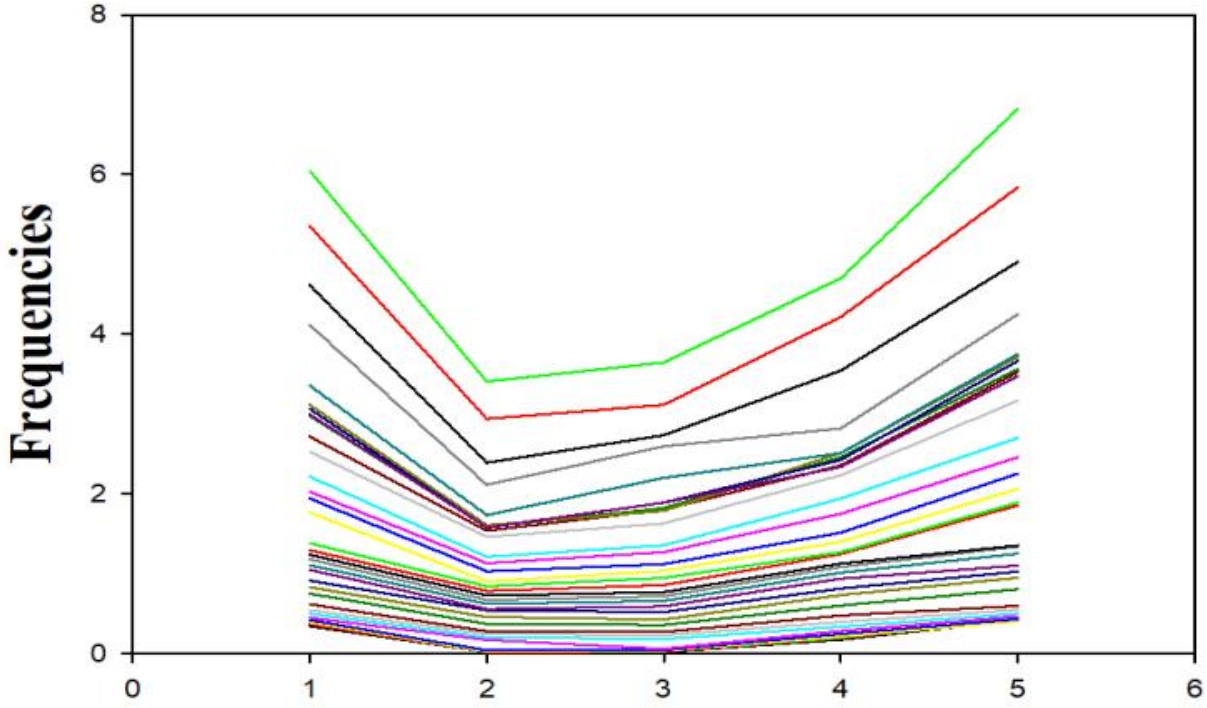
-100
4.19
3.43
3.13
2.58
2.25
1.97
1.64
1.33
1.13
0.947
0.752
0.589
0.448
0.334
0.195

L492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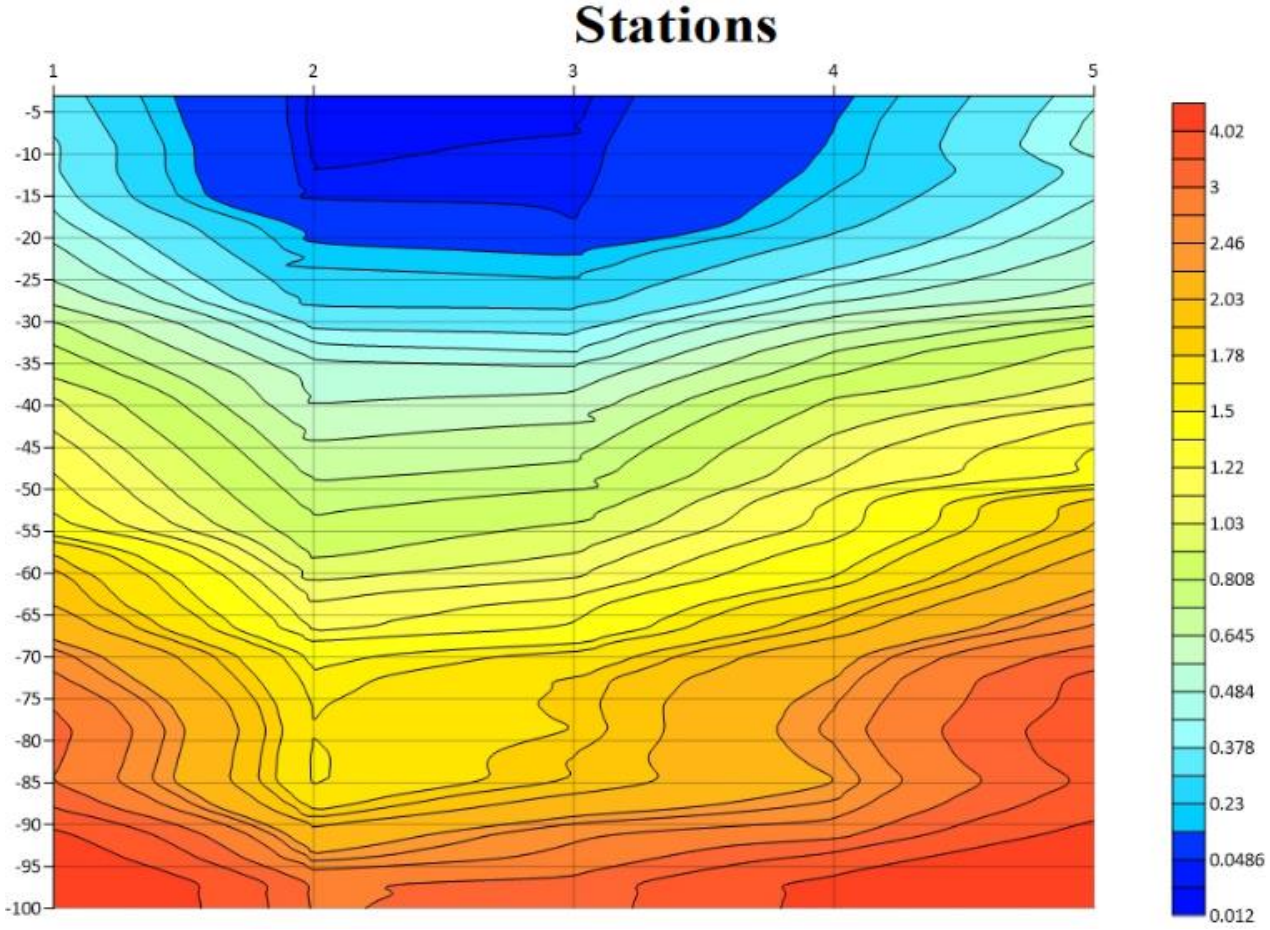
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4.02
3
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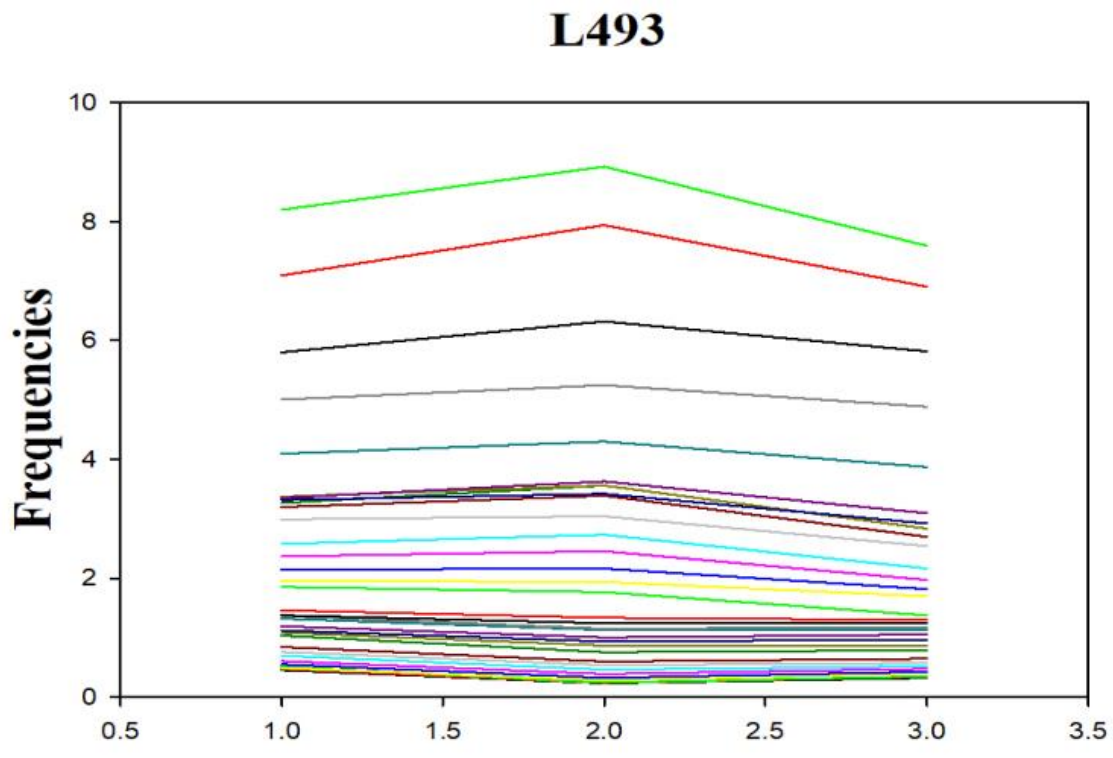
L493
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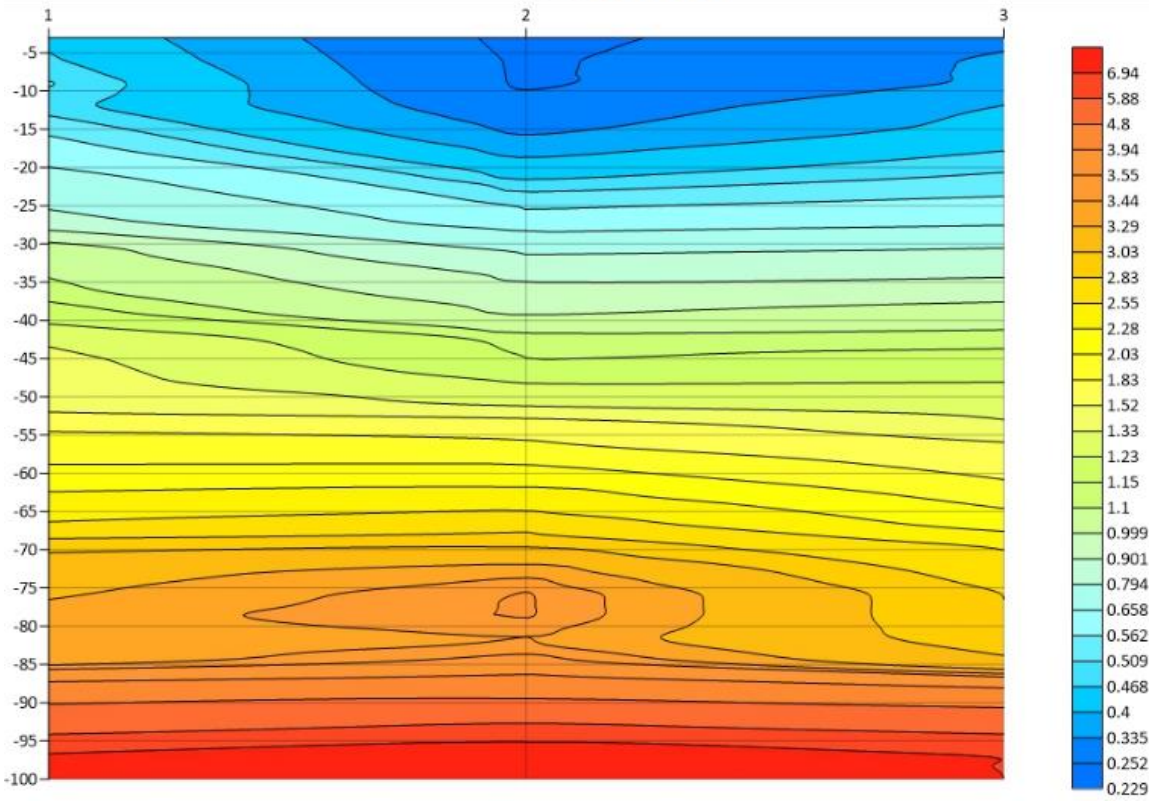
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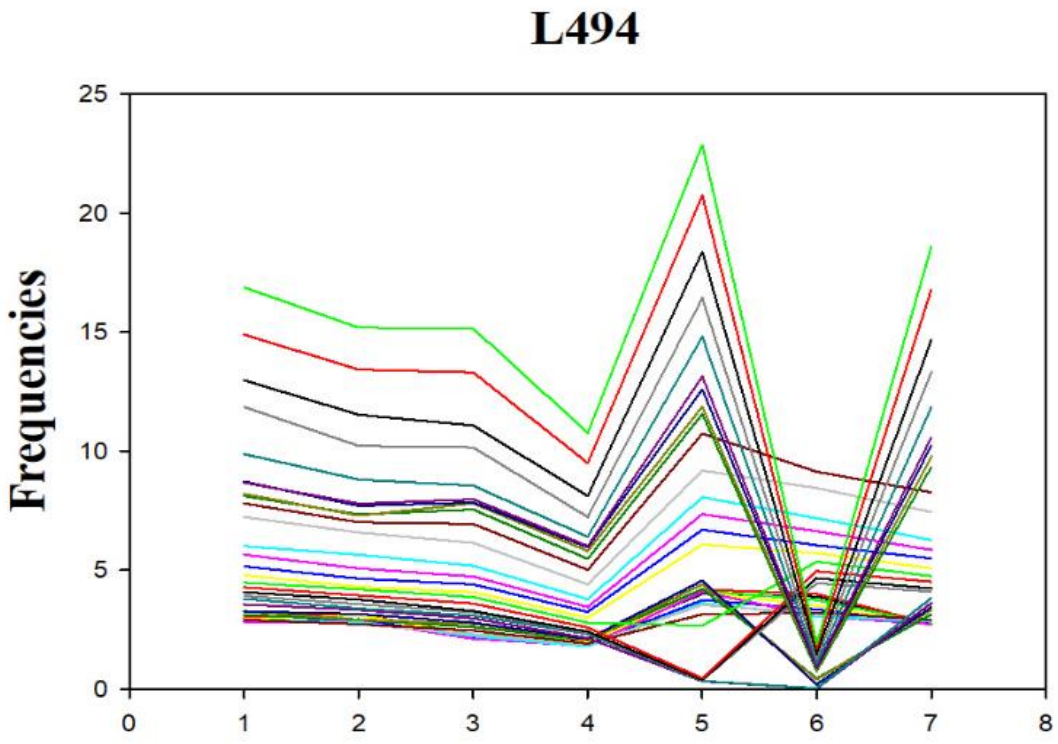
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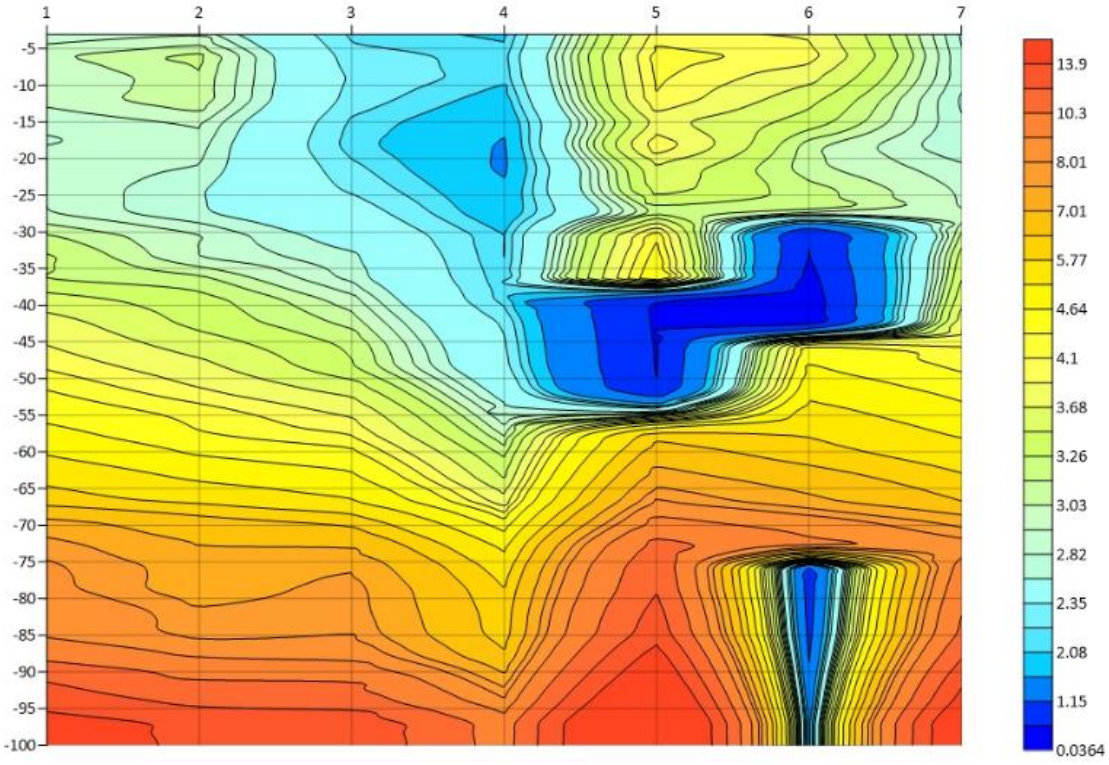
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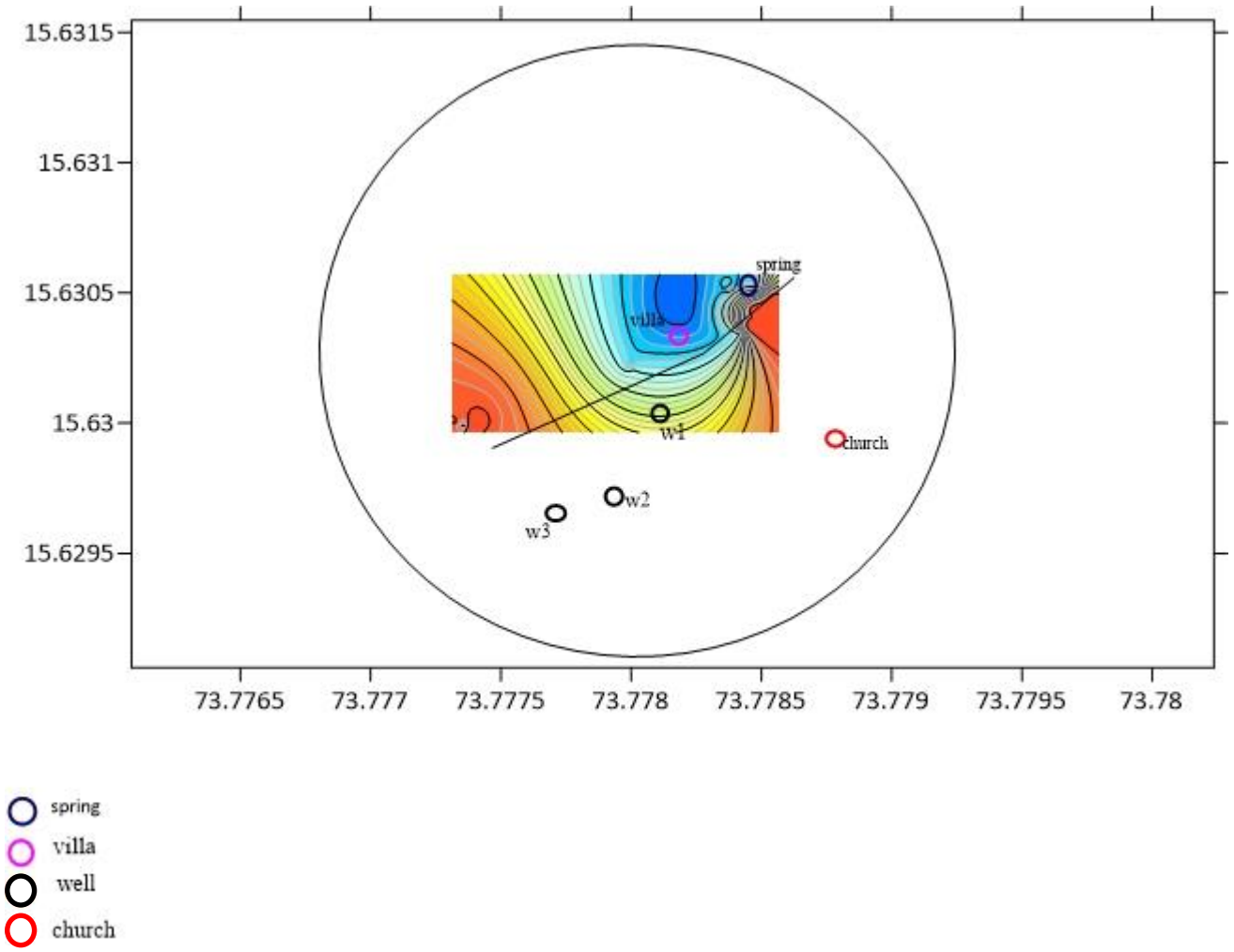

Fig No. 7 Subsoil Water Seepage Map of Oxel Spring of Influence of Survey No. 51/22 indicating various water bearing zones.

Fig No. 7 indicates that the subsoil groundwater flow is towards the spring. The Vadose zone extends up to 3 to 4m depth in the study area. Subsoil water flow from west, south and east directions towards the spring and then it flows further from spring towards the north direction. The area marked in the blue colour contours in the above figure is a hydrogeologically sensitive zone. This a groundwater trough which is accumulating shallow groundwater from nearby catchments. Any surface water which seeps in to the vadose zone will move towards this blue coloured contours and get accumulated. The Oxel Spring lies in the center of this zone.

5.0 CONCLUSIONS

The survey confirmed that the groundwater occurs in unconfined condition. In the middle and lower reaches, the groundwater intersects with the topography and seeps out in the form of springs and waterlogged areas. Thus, forming a wetland ecosystem that supports diverse flora and fauna in the region.

Micro Wetland and Development Concerns:

The micro wetland area, particularly around the natural springs is identified as sensitive. Micro wetlands play crucial roles in maintaining biodiversity, regulating water flow, and providing habitats for various species. Moreover, springs play a vital role in maintaining the ecosystem balance and ecological health of a wetland.

Development Challenges: Any development in the natural zone, especially near the natural springs, poses several challenges:

1. Disruption of natural drainage channels: Developmental activities often disrupt natural drainage patterns, resulting in complete obliteration of first order and second order streams.

2. Contamination of water: Improper sewage discharge or improper waste management can lead to contamination of shallow groundwater sources such as springs, dug wells, ring-wells, and shallow borewells as well as surface water bodies like streams, lakes and ponds.

3. Environmental Impact: Contamination of groundwater and surface water bodies can have adverse environmental consequences, affecting aquatic life, human health as well as the entire ecosystem in the watershed.

From the subsoil water seepage map in Fig.7 it can be inferred that the entire subsoil water flow in the study area is towards the Oxel spring. Any surface water infiltrating in the vicinity of 100 meters radius of the spring will contribute towards the flow of the spring. Any human interventions or development in this area will have direct effect on the water quality of the spring.

The proposed developmental activities as evident by reclamation of the low lying area near the Oxel spring, pose a big danger to the very existence of the spring. The excavation for building foundations and installation of swimming pools could disrupt the natural hydrology of the area, leading to changes in the recharge rate of the spring. Furthermore, the improper handling of chlorinated pool water can introduce harmful chemicals into the surrounding soil and groundwater. Discharge of untreated waste from the settlements to be located near the spring can have negative impact on the ecological health of the spring. Overflow and leakages of septic tanks and soak pits can contaminate the subsoil water.

Hence, a proper engineering measures or care has to be ensured while implementing such development activities in the vicinity of the spring. It is advisable to avoid such development activities within the core zone and buffer zone in interest of the protection of the spring.

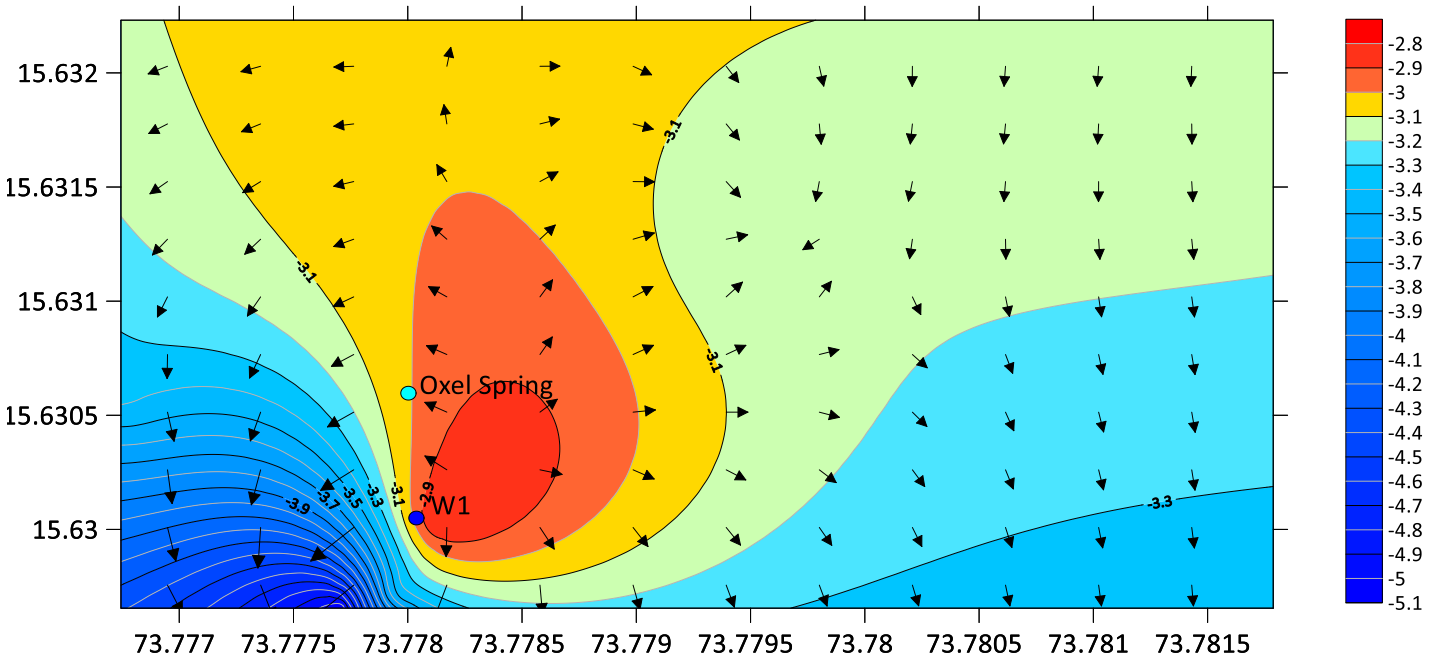

Fig No.8: Groundwater flow net map

Figure 8 illustrates the hydraulic gradient and flow patterns towards and away from the spring, with the blue coloured area being particularly vulnerable to changes in surface as well as subsurface water quality.

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6.0 References

- District Profile of North Goa District, Goa State; Central Groundwater Board (2013)
- Investigation of Wetlands Hydraulic and Hydrological Processes, Model Development, and Application by R. Walton, T. H. Martin, Jr., R. S. Chapman, J. E. Davis (Oct. 1995)
- Hydrogeological assessment of mountainous Mhadei river watershed-Western Ghats region; Ibrampurkar et al (2012)
- Understanding Wetlands Stratigraphy: Geophysics and Soil Parameters for Investigating Ancient Basin Development at Lake Duvensee, Erica Corradini et al (Geosciences, 2020)